USSN 10/525,092

VERIFICATION OF A TRANSLATION

I, the below named translator, hereby declare that:

My name and address are as stated below;

That I am knowledgeable in the English language and the Japanese language and that I believe the hereto attached English translation is a true and complete translation of Japanese Patent Application No. 2002-377241 filed December 26, 2002 based on which the priority right is claimed in connection with the present United States Patent Application Serial Number 10/525,092.

I hereby declare further that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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[Matter] DRAWINGS 1

[Matter] ABSTRACT 1

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[Document] SPECIFICATION

[Title of Invention] FALSE-TWISTED YARN OF POLYLACTIC ACID AND METHOD FOR PRODUCING THE SAME

[Claims]

[Claim 1] A false-twisted yarn of polylactic acid comprising polylactic acid fibers containing a fatty acid bisamide and/or an alkyl-substituted fatty acid monoamide in an amount of 0.1 to 5.0 wt% based on the whole fiber and having the following properties;

strength at 90°C ≧ 0.5 cN/dtex,

CR ≧ 10%, and

Non-untwisted number≦3 spots /10m.

[Claim 2] The false-twisted yarn of polylactic acid according to claim 1, of which the shrinkage in boiling water is 15% or less.

[Claim 3] The false-twisted yarn of polylactic acid according to claims 1 and 2, wherein a polyether-based lubricant is provided.

[Claim 4] The false-twisted yarn of polylactic acid according to claim 3, wherein the polyether-based lubricant is a compound in which an alkylene oxide having 2 to 4 carbon atoms is added by copolymerization to an alcohol having one or more hydroxyl groups in the molecule, and/or a compound derived from these.

[Claim 5] A method for producing a false-twisted yarn of polylactic acid, wherein 1 to 3.0 wt% of a smoothing agent containing 40 wt% or more of a compound in which an alkylene oxide having 2 to 4 carbon atoms is added by copolymerization to an alcohol having one or more hydroxyl groups in the molecule, and/or a compound derived from these is provided to a multifilament

obtained by melt-spinning polylactic acid fibers containing a fatty acid bisamide and/or an alkyl-substituted fatty acid monoamide in an amount of 0.1 to 5.0 wt% based on the whole fiber, an undrawn yarn is obtained by winding up at a spinning speed of 4000 m/min or more, and then the undrawn yarn is subjected to draw-friction false-twist process at the temperature of the false-twisting heater of 90 to 150°C with a ratio (T2/T1) of 3.0 or less of the untwisted tension (T2) to the twisting tension (T1) at the draw-friction false-twist process.

[Detailed Description of Invention]

[0001]

[Art Dield of Invention]

The present invention relates to a false-twisted yarn of polylactic acid that is excellent in heat resistance, wear resistance, and grade, and good in process stability, and a method for producing it.

[0002]

[Conventional Art]

Recently, the development of a polymer material that decomposes in the natural environment is desired for the environmental problem on a global basis, and the research and development of various polymers such as aliphatic polyesters, and the attempt to put them to practical use have been actively performed. Polymers decomposed by microorganisms, that is a biodegradable polymer, have also attracted attention.

[0003]

On the other hand, a conventional polymer mostly uses petroleum resources as a raw material. However, there is concern that petroleum resources may dry up in the future and that carbon dioxide that has been stored

in the ground since the geological age will be released into the air by consuming large amounts of the petroleum resources, and global warming becomes serious. However, if a polymer can be synthesized using plant resources that take in carbon dioxide from air as a raw material, not only is it expected that global warming can be suppressed by the circulation of carbon dioxide, but also there is the possibility that the problem of drying up resources can be solved. Because of this, a polymer using plant resources as a raw material, that is a polymer utilizing biomass, has attracted attention.

[0004]

From the two points described above, a biodegradable polymer utilizing biomass has attracted attention, and it is expected to substitute for conventional polymers using petroleum resources as a raw material. However, the biodegradable polymer utilizing biomass has been a problem bezouse the mechanical characteristics and the heat resistance are generally low and the cost is high. Polylactic acid recently attracts the most attention as a biodegradable polymer utilizing biomass that can solve these problems. Polylactic acid is a polymer using lactic acid as a raw material obtained by fermenting starch extracted from plants, and is the best balancing of mechanical characteristics, heat resistance, and cost among the biodegradable polymers utilizing biomass. Then the development of the fibers using this has been rapidly performed.

[0005]

The development of polylactic acid fibers has been performed prior in agricultural materials, civil engineering materials, etc., making use of the

biodegradable property. However, continuing for a large-scaled use, the interior materials for a car, interior materials such as curtains and carpets, and further application to clothing use are expected. Several drawbacks due to the polymer substrate of polylactic acid are pointed out in developing the polylactic acid fibers for these uses. Among these, heat resistance deficiency and wear resistance deficiency especially have been a problem.

[0006]

There is the problem of heat resistance deficiency of polylactic acid fibers, for example, that dimensional stability of the final product is bad and it cannot endure in practical use because the polylactic acid fibers are easily stretched and deformed when that the temperature of the glass transition point T_g or higher is reached in the field of interior materials for a car used in a high temperature environment, etc. There is the large problem of wear resistance deficiency of polylactic acid fibers, for example, such that the grade decreases at a part undergoing friction such as a shoulder, an elbow, a knee, and a hip part in clothing use due to the occurrence of fluff, shine, etc., and color migration to inner wear occurs.

[0007]

Furthermore, when polylactic acid fibers are developed for clothing use, a crimped yarn is a required item. However, because polylactic acid fibers are easily softened at the temperature of the glass transition point Tg or higher, only using a draw-friction false-twist process applied as it is in general-purpose synthetic fibers, the yarn becomes softened on a false-twisting heater, non-untwisting occurs frequently, and it is difficult to obtain a false-twisting processed yarn that is excellent in crimping property.

[0008]

Conventionally, example methods for producing a false-twisted yarn of polylactic acid to solve the above-described problems are proposed in which an undrawn yarn of polylactic acid is obtained by melt-spinning, the fiber structure is formed by stretching the undrawn yarn of polylactic acid once, and then a false-twisting processing is performed (refer to Patent Documents 1 and 2). However, because three steps of spinning, drawing, and false-twisting are necessary in these methods, there are problems that the productivity is bad and that the cost becomes high. Further, to perform a false-twisting process with two steps using a so-called highly-oriented undrawn yarn as a supplying stock yarn is proposed (refer to Patent Document 3). However, as the result of performing a retest on this, many numbers of non-untwisted spots exist in the false-twisting processed yarn, the strength at 90°C of which the environmental temperature in a car during summer is assumed is 0.4 cN/dtex, and it is found that it is not durable in practical use.

[0009]

Further, in order to improve the characteristics of the polylactic acid fibers, including a surface modifier such as a lubricant to the fibers is proposed (refer to Patent Document 4). The objective of this proposal is to suppress the hydrolysis rate by adding a fatty acid monoamide represented as the general formula $RCONH_2$ (here, R represents an alkyl group) to the polylactic acid fibers, and imparting water repellency. However, there is no description concerning the improvement of wear resistance and ability to smoothly pass through processing steps of polylactic acid fibers, which is the objective of the present invention. By the way, the inventors of the present invention

performed a retest on polylactic acid fibers to which fatty acid monoamide was added. However, the wear resistance of the polylactic acid fibers and the ability to smoothly pass through processing steps at production could not be improved. It is assumed that this is caused by the fatty acid monoamide reacting with the polylactic acid at melting because of the high reactivity of the amide group, and as the result, the ratio of the fatty acid monoamide that can function as a lubricant in the fibers becomes small. Further, because the fatty acid monoamide reacts with the polylactic acid, as the result, a molecular chain of the polylactic acid is cut and the molecular weight decreases, and there is a tendency for the fibrous physical properties decreases.

[0010]

Furthermore, fatty monoamides, having high sublimation property or low heat resistance, it cause deterioration of the operational environment due to the generation of fumes, fouling of guides, rollers or the like due to bleeding out, and deterioration of operating efficiency. The condensation of the fatty acid monoamide bled out on the surface of the fibers causes a physical unevenness and dyeing unevenness. Because of these, a lubricant that improves wear resistance and does not decrease operability has been desired.

[0011]

[Patent Document 1]

Japanese Patent Application Laid-Open (JP-A) No. 2000-290845 (pages 4 to 6)

[0012]

[Patent Document 2]

Japanese Patent Application Laid-Open (JP-A) No. 2002-285438

(pages 3 to 5)

[0013]

[Patent Document 3]

Japanese Patent Application Laid-Open (JP-A) No. 2000-303283 (pages 4 to 5)

[0014]

[Patent Document 4]

Japanese Patent Application Laid-Open (JP-A) No. 1997-183898 (pages 3 to 5)

[0015]

[Problem to be Solved by the Invention]

The objective of the present invention is to provide a false-twisted yarn of polylactic acid excellent in crimping property and dimensional stability while being excellent in ability to smoothly pass through processing steps and productivity and being able to endure in use under a high temperature environment and in the field of which wear resistance is demanded, and a method of producing the same.

[0016]

[Means to Solve the Problem]

The false-twisted yarn of polylactic acid of the present invention consists of polylactic acid fibers containing a fatty acid bisamide and/or an alkyl-substituted fatty acid monoamide in an amount of 0.1 to 5.0 wt% based on the whole fiber and has the following properties.

[0017]

Strength at 90°C $\geqq$ 0.5 cN/dtex.

CR ≧ 10%.

Non-untwisted number≦3 spots /10m.

Further, the false-twisted yarn of polylactic acid in the present invention can be produced by providing 1 to 3.0 wt% of a smoothing agent containing 40 wt% or more of a compound in which an alkylene oxide having 2 to 4 carbon atoms is added by copolymerization to an alcohol having one or more hydroxyl groups in the molecule, and/or a compound derived from these, to a multifilament obtained by melt-spinning polylactic acid fibers containing a fatty acid bisamide and/or an alkyl-substituted fatty acid monoamide in an amount of 0.1 to 5.0 wt% based on the whole fiber, by obtaining an undrawn yarn by winding up at a spinning speed of 4000 m/min or more, and by subjecting the undrawn yarn to a draw-friction false-twist process at the temperature of the false-twisting heater of 90 to 150°C with a ratio (T2/T1) of 3.0 or less of the untwisted tension (T2) to the twisting tension (T1) at the draw-friction false-twist process.

[0018]

[Embodiments of the Invention]

The false-twisted yarn of polylactic acid in the present invention consists of polylactic acid fibers containing a fatty acid bisamide and/or an alkyl-substituted fatty acid monoamide.

[0019]

The polylactic acid referred to in the present invention is one produced by polymerizing an oligomer of lactic acid such as lactic acid and lactide, and when optical purity of the L form or D form is 90% or more, the melting point is high and it is a preferable embodiment. Further, in the range of

not losing characteristics of polylactic acid, a component other than lactic acid may be copolymerized, and may include polymers and particles other than polylactic acid, as well as additives such as a flame retardant, an antistatic agent, and a deglossing agent. However, from the point of view of utilizing biomass and biodegradability, it is important to make a polylactic acid monomer as a polymer 50 wt% or more. The polylactic acid monomer is preferably 75 wt% or more, and more preferably 96 wt% or more.

[0020]

However, besides the above-described system in which two types of optical isomers are simply mixed, it is more preferable to blend the above-described two types of optical isomers and mold it into fibers, and then to make it into a stereo-complex in which a racemic crystal is formed by performing high temperature heat treatment at 140°C or higher because the melting point can be elevated rapidly.

[0021]

At this time, polymers such as polyethylene terephthalate, poly-trimethylene terephthalate, polybutylene terephthalate, nylon, polybutylene succinate, and polyhydroxybutylate may be blended or conjugated in the part other than the polylactic acid monomer in the range of not losing performances of polylactic acid. Furthermore, from the point of view of maintaining biomass and biodegradability, other biodegrable polymers such as polybutylene succinate and polyhydroxybutylate are more preferably used. The blend of these polymers may be a chip blend or a melt blend, and the conjugation may be a core-sheath conjugation or a side-by-side conjugation. If the weight-average molecular weight of the polylactic acid is 50,000 to 500,000, the

balancing of mechanical properties and fiber productivity is good. The molecular weight of the polylactic acid is more preferably 100,000 to 350,000 in weight-average molecular weight.

[0022]

The method for producing the polylactic acid used in the present invention is not especially limited. A specific example includes the method for producing that is disclosed in Japanese Patent Laid-Open Publication No.1994-65360. That is, it is a direct dehydration and condensation method of dehydrating and condensing polylactic acid as it is under the existence of an organic solvent and a catalyst. Further, there is the method disclosed in Japanese Patent Laid-Open Publication No.1995-173266 in which at least two types of homo-polymer are copolymerized and subjected to an ester interchange reaction under the existence of a polymerization catalyst. Furthermore, there is the method disclosed in U.S. Patent No. 2,703,316. That is, it is an indirect polymerization method in which lactic acid is made to a cyclic dimmer, and then a ring-opening polymerization is performed.

[0023]

In the present invention, a fatty acid bisamide and/or an alkyl-substituted fatty acid monoamide are/is included in the fibers consisting of polylactic acid (polylactic acid fibers) as a lubricant.

[0024]

The fatty acid bisamide used in the present invention indicates a compound having two amide bonds in one molecule of saturated fatty acid bisamide, unsaturated fatty acid bisamide, aromatic bisamide, etc., and examples include methylene biscapryl amide, methylene biscapric amide,

methylene bislauric amide, methylene bismyristic amide, methylene bispalmitic amide, methylene bisstearic amide, methylene bisisostearic amide, methylene bisbehenic amide, methylene bisoleic amide, methylene biserucic amide, ethylene biscapryl amide, ethylene biscapric amide, ethylene bislauric amide, ethylene bismyristic amide, ethylene bispalmitic amide, ethylene bisstearic amide, ethylene bisisostearic amide, ethylene bisbehenic amide, ethylene bisoleic amide, ethylene biserucic amide, butylene bisstearic amide, butylene bisbehenic amide, butylene bisoleic amide, butylene biserucic amide, hexamethylene bisstearic amide, hexamethylene bisbehenic amide, hexamethylene bisoleic amide, hexamethylene biserucic amide, m-xylylene bisstearic amide, m-xylylene bis-12-hydroxystearic amide, p-xylulene bisstearic amide, p-phenylene bisstearic amide, p-phenylene bisstearic amide, N,N'-distearyl adpic amide, N,N'-distearyl sebacic amide, N,N'-dioleyl adpic amide, N,N'-dioleyl sebacic amide, N,N'-distearyl isophthalic amide, methylene bishydroxystearic amide, ethylene bishydroxystearic amide, butylene bishydroxystearic amide, and hexamethylene bishydroxystearic amide.

[0025]

Further, the alkyl-substituted fatty acid monoamide used in the present invention indicates a compound having a structure in which an amide hydrogen of saturated fatty acid monoamide, unsaturated fatty acid monoamide and the like is substituted with an alkyl group, and examples include N-lauryl lauric amide, N-palmityl palmitic amide, N-stearyl stearic amide, N-behenyl behenic amide, N-oleyl oleic amide, N-stearyl oleic amide, N-oleyl stearic amide, N-stearyl erucic amide, and N-oleyl palmitic amide. Here, a substituent such as a hydroxyl group may be introduced in the structure of the alkyl group,

and examples such as methylol stearic amide, methylol behenic amide, N-stearyl-12-hydroxystearic amide, and N-oleyl-12-hydroxystearic amide are included in the alkyl-substituted fatty acid monoamide in the present invention.

[0026]

In the present invention, a fatty acid bisamide and an alkyl-substituted fatty acid monoamide are used. However, these compounds have a lower reactivity of amide compared to fatty acide monoamide, and at melt-molding, it is difficult for the reaction with polylactic acid to occur. Further, because many of these compounds have a large molecular weight, they generally have characteristics that heat resistance is good and it is difficult to sublimate. Among these compounds, especially fatty acid bisamide is used more preferably because it has a lower reactivity of amide, is excellent in heat resistance, and it is difficult to sublimate.

[0027]

In the present invention, it is important to contain a fatty acid bisamide and/or an alkyl-substituted fatty acid monoamide in an amount of 0.1 to 5.0 wt% based on the whole fiber as a lubricant. By making the containing amount of a fatty acid amide and/or an alkyl-substituted fatty acid monoamide to 0.1 wt% or more, the surface frictional coefficient of the fibers decreases and wear resistance demanded on fiber products in the use of clothing and durability in repeated use can be provided. Furthermore, because the frictional resistance decreases between fibers and the fibers are excellent in migration property in the draw-friction false-twist process, the non-untwisted spots are hard to occur in the obtained false-twisted yarn, and the grade improves. Further, by making the containing amount of a fatty acid amide

and/or an alkyl-substituted fatty acid monoamide to 5 wt% or less, fatty acid amide can be finely dispersed and the physical unevenness and the dyeing unevenness of the fibers can be prevented. The containing amount of the fatty acid amide and/or the alkyl-substituted fatty acid monoamide is preferably 0.2 to 3 wt%. In the present invention, only one of the fatty acid amide or the alkyl-substituted fatty acid monoamide may be used or a plurality of the components may be mixed, and in the case of being mixed, 0.1 to 5 wt% of the mixture may be contained based on the whole fiber.

[0028]

The undrawn yarn of polylactic acid before the false-twisted yarn of polylactic acid in the present invention is obtained is preferably oriented and crystallized in order to secure heat resistance on the false-twisting heater in the draw-friction false-twist process. Because the undrawn yarn of polylactic acid that is oriented and crystallized is hard to soften at high temperature, it is possible to perform a stable draw-friction false-twist process, and both dimensional stability and crimping property of the obtained false-twisted yarn of polylactic acid become excellent. Further, the shrinkage in boiling water can be used as a standard of the oriented crystallization of the undrawn yarn of polylactic acid, and the shrinkage in boiling water of the undrawn yarn of polylactic acid is preferably 20% or less.

[0029]

It is important for the false-twisted yarn of polylactic acid in the present invention that a maximum point strength when a tensile test is performed in an atmosphere at 90°C (below, more briefly mentioned as strength at 90°C) is 0.5 cN/dtex or more. If the strength at 90°C is 0.5 cN/dtex or more,

the dimensional change of the final product can be suppressed at use in an atmosphere at high temperature and the dimensional change of cloth due to heating in the gluing process and the drying process is small. The strength at 90°C is preferably 0.6 cN/dtex or more, and further preferably 0.8 cN/dtex or more.

[0030]

It is important for the false-twisted yarn of polylactic acid in the present invention that the CR value, which is an indication of crimp property, is 10% or more. When the CR value is 10% or more, good bulkiness and stretchiness can be obtained in the final product. The CR value is preferably 15% or more, and more preferably 20% or more.

[0031]

Further, it is important for the false-twisted yarn of polylactic acid in the present invention that the non-untwisted number per 10 m of the false-twisted is 3 spots or less. If the non-untwisted parts are 3 spots / 10m or less, a dyed cloth excellent in uniformity and having a grade that is durable in practical use can be obtained, and dyeing unevenness can be suppressed. The non-untwisted number is preferably 1 spot / 10m or less , and more preferably 0 spot / 10 m.

[0032]

Further, in the false-twisted yarn of polylactic acid in the present invention, if the shrinkage in boiling water is 15% or less, the dimensional stability of the false-twisted yarn and the fiber product are good and it is a preferred embodiment. The shrinkage in boiling water is more preferably 10% or less, and further preferably 8% or less. Further, the shrinkage in boiling

water is preferably 0% or more because the fiber product does not stretch in the case a heat treatment is performed and dimensional stability improves.

[0033]

In the method for producing a false-twisted yarn of polylactic acid in the present invention, it is important that a fatty acid bisamide and/or an alkyl-substituted fatty acid monoamide, which lower the surface frictional coefficient, are/is added in the fibers of polylactic acid constituting the false-twisting yarn of polylactic acid, and preferably it is important that a spinning oil containing a polyether-based lubricant (finishing oil) is given. The polyether-based lubricant can suppress the adhesion of tar on the heater and the adhesion of scum to the twister and guides in the draw-friction false-twist process because it is excellent in heat resistance.

[0034]

Further, because a lubricant for lowering the surface frictional coefficient is added in the false-twisted yarn of polylactic acid in the present invention, the frictional coefficient between the fibers and metal is low, and in the draw-friction false-twist process, the fibers slip on the twisting body, the threading property and twisting-up property are poor, and only a false-twisted yarn of low crimping performance can be obtained. Then, because it becomes possible to raise the frictional coefficient between the fibers and metal by providing the polyether-based lubricant proposed in the present invention to the fibers, the above-described problem can be solved. Furthermore, because the frictional coefficient between the fibers can be decreased by giving the polyether-based lubricant in the present invention, the migration property is improved on the false-twisting heater, non-untwisting can be suppressed, and

the grade of the final product can be improved.

[0035]

It is a preferred embodiment to contain 40 wt% or more of the polyether-based lubricant in the pure spinning oil content because staining of the heater, staining of guides, and staining of the surface of the twisting body can be suppressed and the cleaning cycle and replacing cycle of the draw-friction false-twist process apparatus can be prolonged. Furthermore, because it becomes possible to decrease friction between the fibers, fluffing when passing processes is suppressed and the migration property is improved. Therefore, the grade of the false-twisted yarn is improved. The ratio of the polyether-based lubricant in the pure spinning oil content is more preferably 60 wt%, and further preferably //79 wt% or more.

[0036]

The polyether-based lubricant preferably used in the present invention includes a compound in which an alkylene oxide having 2 to 4 carbon atoms is added by copolymerization to an alcohol having one or more hydroxyl groups in the molecule, and a compound derived from these.

[0037]

Here, an alcohol having one or more hydroxyl groups in the molecule includes any natural or synthetic monohydric alcohol having 1 to 30 carbon atoms (methanol, ethanol, isopropanol, butanol, isoamyl alcohol, 2-ethyl hexanol, lauryl alcohol, isotridecyl alcohol, isocetyl alcohol, stearyl alcohol, and isostearyl alcohol, etc.), dihydric alcohol (ethylene glycol, propylene glycol, neopentyl glycol, hexylene glycol, etc.), and trihydric or higher alcohol (glycerine, trimetylol propane, pentaerythritol, sorbitan, sorbitol, etc.).

[0038]

Further, alkylene oxide having 2 to 4 carbon atoms includes ethylene oxide (hereiafter, abbreviated as EO), 1,2-propylene oxide (hereinafter, abbrevieated as PO), 1,2-butylene oxide (hereinafter, abbreviated as BO), and tetrahydrofuran (hereinafter, abbreviated as THF).

[0039]

In the case of copolymerizing EO and other alkylene oxides, the ratio of EO is preferably 5 to //79 wt% for the balancing of the viscosity when it is made to be aqueous solution or aqueous emulsion and the heat resistance on the heater in the draw-friction false-twist process, etc. Further, the way of addition may be any of a random addition or a block addition.

[0040]

Furthermore, when the weight-average molecular weight of the polyether-based lubricant is in the range of 500 to 30,000, the balancing of the viscosity when it is made to be aqueous solution or aqueous emulsion and the heat resistance on the heater in the draw-friction false-twist process, etc. is good, it is more preferably in the range of //790 to 20,000, and most preferably in the range of 1200 to 15000.

[0041]

The compound derived from the above-described copolymerization-addition compound of alkylene oxide includes a compound in which a terminal hydroxyl group is alkoxylated and/or acylated with an alkyl group having 1 to 12 carbon atoms, a compound in which the terminal hydroxyl group is esterified with dicarbonic acid having 2 to 12 carbon atoms, and a

compound in which the terminal hydroxyl group is urethanized with an alphatic or an aromatic diisocyanate compound.

[0042]

Specific examples of the polyether-based lubricant include [butanol (EO/PO) random addition, EO/PO = 50/50 wt%, weight-average molecular weight = 1400], [hexylene glycol (EO/PO) random addition, EO/PO = 40/60 wt%, weight-average molecular weight = 4000], and [methylether of trimethylol propane (PO) (EO) block addition, EO/PO = 20///79 wt%, weight-average molecular weight = 5000] , etc. However, it is not limited to these.

[0043]

It is important that the finishing oil for spinning including the polyether-based lubricant used in the present invention has a polyether-based lubricant as a main component. However, arbitrary other components may be included at a level without losing the performances. Examples of arbitrary other components include a smoothing agent (mineral oil and fatty acid ester), an antistatic agent (an anionic surfactant, a cationic surfactant, an amphoteric surfactant, etc.), and an emulsifier (a higher alcohol addition, a higher fatty acid EO addition, etc.).

[0044]

The above-described finishing oil for spinning is preferably provided to the false-twisted yarn of polylactic acid in the present invention at 0.1 to 3.0 wt% in pure content based on the whole fibers. If the adhesion amount is 0.1 wt% or more, it is possible to sufficiently demonstrate the performance as the finishing oil such as convergence and lubricating property, and when the adhesion amount is 3.0 wt% or less, stable production is possible without

contaminating the equipment by the finishing oil component falling off during the process and without inviting deterioration of ability to smoothly pass through processing steps due to the contamination. Furthermore, if the finishing oil for spinning is given in the above-described range, the migration is improved because the friction between fibers can be decreased sufficiently in the draw-friction false-twist process, and additionally the twisting-up property is improved because the friction between the fibers and metal becomes high reversely, and there is no yarn breakage on the heater. Therefore, it is preferable. The adhesion amount of the finishing oil for spinning is more preferably 0.2 to 2.0 wt% for the above-described reason, and most preferably 0.2 to 1.5 wt%.

[0045]

Further, if the total fineness of the false-twisted yarn in the present invention is in the range 10 to 500 dtex, it is a preferred embodiment because handleability and the thickness of the fabric can be optimized.

[0046]

Further, if the single fiber fineness of the false-twisted yarn of polylactic acid in the present invention is in the range of 0.1 to 20 dtex, it is preferable because the balancing of bulky feeling, softness feeling, touch, etc of the obtained cloth is good.

[0047]

Furthermore, the cross-sectional shape of the fibers (the single fiber) of polylactic acid constituting the false-twisted yarn of polylactic acid in the present invention is not especially limited. However, examples include a hollow section and a core-sheath conjugated section. At this time, if it is a

hollow section, in addition to the heat retaining effect due to the crimping shape of the false-twisted yarn of polylactic acid, a further heat retaining effect can be provided because it has a space inside a single yarn.

[0048]

Further, the fiber structure using the false-twisted yarn of polylactic acid in the present invention is not especially limited. However, the crimping property, heat resistance, and wear resistance can be utilized effectively by making it into a fabric. Furthermore, examples of the fiber structure include the interior of a car, curtains, interior furnishings, sports wear, and linings.

[0049]

Next, the method for producing the false-twisted yarn of polylactic acid in the present invention is described by exemplifying in order to deepen the understanding. However, the method for producing the false-twisted yarn of polylactic acid is not limited by the method described below in any way.

[0050]

First, the polylactic acid polymer as a raw material can be synthesized using a known method as already described. However, it is preferable to make the tone of color of polylactic acid itself good and to reduce the remaining oligomer and monomer of lactide, etc. In the specific example of the method, as described in Japanese Patent Application Laid-Open No. 1995-504939, a metal deactivator and an anti-oxidizing agent are preferably used, and lowering of the polymerization temperature and suppression of the adding amount of catalyst are preferably performed. Further, by treating the polymer at reduced pressure and extracting with chloroform, the amount of the remaining oligomer and monomer can be decreased by a large amount.

Further, other polymers and particles, an antistatic agent, a deglossing agent, etc. may be added in a range that the characteristic of polylactic acid is not lost at synthesis.

[0051]

The weight-average molecular weight of polylactic acid preferably used in the method for producing the false-twisted yarn of polylactic acid in the present invention is 5 to 500,000. The weight-average molecular weight of this range is preferable because the balancing of processability and mechanical properties of the obtained fibers is good. Furthermore, polylactic acid is preferably dried in vacuum at a temperature of 90 to 110°C. By performing the drying with this condition, moisture and oligomer such as lactide remaining in the polylactic acid are removed effectively and there is no fusion of the polylactic acid polymers.

[0052]

In the method for producing the false-twisted yarn of polylactic acid in the present invention, when an undrawn yarn of polylactic acid to be supplied to the draw-friction false-twist process is obtained, polylactic acid may be supplied directly to a spinning machine without undergoing the drying process after it was polymerized, or it may be supplied to a spinning machine after undergoing the drying process once. Further, a melt spinning is preferably used to obtain the undrawn yarn of polylactic acid to be supplied to the draw-friction false-twist process. However, an extruder type melt extruder and a pressure-melter type melt extruder can be preferably used as an extruder. Further, the method for adding a lubricant is not especially limited. However, the methods include a method for obtaining a raw material polymer by putting

the lubricant at a stage of synthesis, a method for producing a master article by first melting and kneading the raw material polymer and the lubricant, a method for mixing the master article and the raw material polymer and supplying, a method for measuring and adding the melted lubricant from the middle of the extruder type melting extruder process, and a method for adhering the lubricant to the raw material polymer in the drying process. Among these, from the respect that the adhesion amount of the lubricant is difficult to be changed, a method other than the method for adhering the lubricant to the raw material polymer in the drying process is preferably applied. Furthermore, the method for measuring and adding the melted lubricant from the middle of the extruder type melting extruder process is a preferred embodiment because thermal decomposition of the lubricant can be suppressed and coloring becomes less. Furthermore, other polymers and particles, an antistatic agent, a deglossing agent, etc. may be added in a range that characteristics of polylactic acid are not lost.

[0053]

Here, after the melted and extruded polymer is measured at a fixed amount through a measuring pump, it is introduced to a spinning pack arranged inside a heated spin block. Furthermore, a filtration is performed in the spinning pack to remove foreign objects, and the yarn-thread of polylactic acid spanned out from a spinneret and cooled and solidified in a cooling apparatus is converged in a finishing oil feeding apparatus, and at the same time the finishing oil for spinning is provided. Here, because there is the case that the operational environment deteriorates by low molecular weight substances such as lactide accompanied by thermal decomposition of polylactic acid and the

added lubricant sublimating and volatizing, a suction device can be provided under the spinneret if necessary.

[0054]

The finishing oil for spinning including the polyether-based lubricant used in the present invention referred to here is provided to the yarn-thread right after the spinning as aqueous solution or aqueous emulsion in the finishing oil feeding apparatus.

[0055]

Concentration of the aqueous solution or the aqueous emulsion is preferably set to an arbitrary concentration within 0.5 to 20 wt% in the respects of the adhesion efficiency to the fibers, and viscosity and film-forming performance of the aqueous solution and of the aqueous emulsion. The concentration is more preferably 5.0 to 1//79 wt%.

[0056]

The method for providing the aqueous solution and the aqueous emulsion is not especially limited, and oil metering and feeding through a nozzle, oil feeding through a roller, or a combination of these may be used. Further, in the case of feeding oil at high speed to the undrawn yarn of polylactic acid at spinning, the oil metering and feeding using a nozzle is especially preferably used.

[0057]

The undrawn yarn of polylactic acid which was converged and fed with oil in the finishing oil feeding apparatus is wound up in the winding-up device through a non-heated first take-up roller and a second take-up roller. Here, the circumferential velocity of the first take-up roller is made to be the

spinning speed referred to in the present invention. Further, a fluid treatment apparatus may be provided in an arbitrary location from the finishing oil feeding apparatus to the first take-up roller, the second take-up roller and the winding-up device to give the converging property to the undrawn yarn of polylactic acid and improve unreelability of the cheese. Moreover, fluid used in the fluid treatment apparatus includes air flow and water flow. The fluid used in the fluid treatment apparatus includes air flow and water flow. However, if it is air flow, sufficient converging property and unreelability can be given to the yarn-thread running at high speed. Further, from a point of view of preventing yarn sway and performing stable production, the velocity of the first take-up roller (V1) and the velocity of the second take-up roller (V2) are preferably in the range of $0.99 \leqq V2/V1 \leqq 1.05$.

[0058]

Because the polylactic acid fibers are oriented and crystallized and the fiber structure is developed when the spinning speed is 4,000 m/min or more, the heat resistance improves, softening of the yarn-thread can be suppressed on the heater, and process stability improves. Further, by subjecting the highly oriented and crystallized polylactic acid fibers to the draw-friction false twist process at high temperature, heat resistance, that is strength at 90°C, improves. It is difficult to draw further the once oriented and crystallized fibers such as polyethylene terephthalate used for general-purpose except a special condition, and it is considered that this is a unique characteristic of polylactic acid. The reason why the strength at 90°C improves by performing the draw-friction false-twist process, that is drawing, on the once oriented and crystallized fibers is not clear. However, it is considered

that when polylactic acid is heated and a stress is applied in the direction of a fiber axis, it partially re-crystallizes by a molecular chain drawn out from a crystal because the interaction between the molecules of polylactic acid is weak, a non-crystal layer connecting the crystals plays a role of a tie molecule having a high binding property, and elongation and deformation at high temperature are suppressed. Furthermore, if the spinning speed is in an appropriate range, there is less yarn breakage in the melt spinning process and stable production becomes possible. Because of this, the spinning speed is preferable 4,250 m/min to 7,000 m/min, and further preferably 4,500 m/min to 6,500 m/min.

[0059]

A false-twist process is performed on the undrawn yarn of polylactic acid which was wound up in the draw-friction false-twist process apparatus. The undrawn yarn of polylactic acid supplied to the draw-friction false-twist process apparatus is sent to a supplying roller through a desired yarn guide and the fluid process apparatus. After that, it is introduced to a drawing roller through a heated false-twisting heater, a cooling plate, and a twisting body that performs draw-friction false-twisting, and wound up as a false-twisted yarn.

[0060]

In the present invention, as for the draw-friction false-twisting, the friction false-twist process may be performed after the drawing by a heat pin and a hot plate was added before the supplying roller of the draw-friction false-twist process apparatus, and the friction false-twist process may be performed while being drawn between the supplying roller and the drawing roller. At this time, the method for performing the friction false-twist process while being drawn between the supplying roller and the drawing roller is

preferable because there is no need to provide a heat pin and a hot plate, the cost of equipment can be made low, there is less exchanging parts, and it is excellent in cost.

[0061]

Further, in the draw-friction false-twist process referred to in the present invention, the temperature of the false-twisting heater, that is the false-twist process temperature, is preferably set in the range of 90 to 150°C. Because the orientation and crystallization are proceeding in the undrawn yarn of polylactic acid in the present invention, heat resistance on the heater improves, and because the yarn-thread is not softened and steadily run on the heater with high temperature at the above-described process temperature, in addition to a stable draw-friction false-twist process without yarn breakage becoming possible, both the dimensional stability and the crimping property of the obtained false-twisted yarn improve.

[0062]

When the false twist process temperature is 90°C or more, sufficient dimensional stability can be given to the obtained false-twisted yarn, and when the temperature is 150°C or less, a stable draw-friction false-twist process without yarn breakage on the heater can be performed, and because the balancing of deformation due to heat and heat fixation is good, the obtained false-twisted yarn becomes excellent in dimensional stability, crimping property, and quality. For the above-described reason, the false twist process temperature is more preferably in the range of 95 to 145°C, and most preferably in the range of 100 to 140°C.

[0063]

In the present invention, in the case of performing the draw-friction false-twist process by supplying the undrawn yarn of polylactic acid obtained by the above-described method, it is necessary that the ratio (T2/T1), the untwisted tension (T2) to the twisting tension (T1), is 3.0 or less. When the ratio T2/T1 is 3.0 or less, that is the case that the untwisted tension (T2) is small, because the generation of fluffing can be suppressed, the non-untwisted spots can be decreased, and the yarn breakage after the twisting body becomes less, a stable draw-friction false-twist process becomes possible, and the obtained false-twisted yarn becomes excellent in grade. Because of this, T2/T1 is preferably 0.1 to 2.8, and more preferably 0.5 to 2.5.

[0064]

Further, in the draw-friction false-twist process in the present invention, the ratio of the surface speed of the twisting body to the running speed of the yarn-thread, which is the velocity of the drawing roller (the surface speed of the twisting body / the running speed of the yarn-thread) is preferably in the range of 1.0 to 2.5. By making (the surface speed of the twisting body / the running speed of the yarn-thread) to 1.0 or more, the draw-friction false-twist process can be performed with the good balancing of the twisting tension (T1) and the untwisted tension (T2) and without fluffing and yarn breakage. Further, by making (the surface speed of the twisting body / the running speed of the yarn-thread) to 2.5 or less, surface friction of the twisting body is suppressed, in addition to the quality in the longitudinal direction of the yarn becoming stable even after continuous driving for a few tens of hours, shaving of the yarn due to the friction of the yarn-thread of polylactic acid and the twisting body is suppressed and the draw-friction false-twist process without

fluffing and yarn breakage can be realized. (the surface speed of the twisting body / the running speed of the yarn-thread) is preferably in the range of 1.2 to 2.2, and more preferably in the range of 1.25 to 2.0.

[0065]

In the draw-friction false twist process in the present invention, the twisting body is not especially limited. However, a three-axial friction false-twisting device, a belt nip type friction false-twisting device, etc. can be used. The polylactic acid deforms very sensitively to heat and is weak against wear, and deformation on the twisting body and shaving of the yarn-thread easily occur. In order to prevent this, for example, a urethane disk may be used as a disk of the three-axial friction false-twisting device. By making the surface of the disk flexible urethane, the deformation of the polylactic acid fibers and the shaving of the yarn-thread can suppressed. The hardness of the urethane disk is preferably in the range of 75 to 90 degree in JIS A scale because the sectional deformation of polylactic acid and the shaving of the fyarn-thread can be suppressed and the exchanging cycle due to wear of the disk can be prolonged, and most preferably it is in the range of //79 to 85 degree.

[0066]

Further, in the draw-friction false-twist process in the present invention, a belt nip type friction false-twisting device can be used. The crossing angle of the belt is not especially prescribed. However, if it is in the range of 90 to 120°, sufficient twist can be performed on the yarn-thread, and wear of the belt can be suppressed. A flexible material is preferably used as the belt material to suppress the deformation of the polylactic acid fibers and

the shaving of the yarn-thread, and chloropylene rubber and nitrilebuthylene rubber can be preferably used. At this time, nitrilebutylene rubber (NBR) is more preferable in the respect of durability, cost, and flexibility. Furthermore, from the point of view of prolonging the exchange cycle of the belt, hardness is necessary at some level. Specifically, the preferred hardness to achieve the above-described objective is in the range of 60 to 72 degree in JIS A scale. The further preferred hardness is in the range of 65 to 70 degree.

[0067]

Further, the disk configuration of the three-axial friction false-twisting device that can be used in the present invention is not especially limited. However, if the disk is configured only with urethane disks and the number of the urethane disks is in the range of 5 to 12, the draw-friction false twist process can be performed without problems. Further, in order to suppress the yarn breakage due to the impact when the yarn is guarded, a disk of ceramic material can be used in the first and the last disk of the three-axial friction false-twisting device. Because the yarn slips on the surface of the disk when the yarn is guarded by making the disk material ceramic, unreasonable tension does not apply to the yarn-thread. Further, the preferred embodiment is that 2 to 4 ceramic desks are arranged in the yarn-thread supplying side of the three-axial friction false-twisting device.

[0068]

Furthermore, in the method for producing a false-twisted yarn of polylactic acid in the present invention, a heat treatment can be performed by arranging a heater and a delivery roller between the drawing roller and the winding-up apparatus. By performing the heat treatment, the dimensional

stability of the false-twisted yarn of polylactic acid can be improved further. Further, the type of the heater is not especially limited, and a contact type heater and a non-contact type heater can be used. Further, if a nip roller and a belt nip apparatus are arranged in the delivery roller, the yarn can be sufficiently grasped. The temperature of the heater is not especially limited. However, it is preferably in the range of 100 to 250°C considering the efficiency of the heat treatment and the melting point of the polylactic acid. Further, in the case of using a non-contact type heater, because the efficiency of the heat treatment decreases, the heat treatment can be performed sufficiently without yarn breakage if it is in the range of 150 to 350°C. Further, the ratio (VD/VE) of the velocity of the delivery roller (VD) to that of the drawing roller (VE) is not especially limited. However, stable heat treatment without yarn breakage can be performed if it is in the range, $0.8 \leqq VD/VE \leqq 1.0$.

[0069]

[Examples]

Below, the false-twisted yarn of polylactic acid and the method for producing the same in the present invention are explained in detail.
Moreover, the methods as described below were used as methods for measuring values described in the Examples.

[0070]

A. Weight-average molecular weight of polylactic acid

A measurement solution is made by mixing THF into a chloroform solution of the sample. It is measured with GPC and a weight-average molecular weight in terms of polyethylene is obtained.

[0071]

B. Intrinsic viscosity of polyester [η]

It is measured in orthochlorophenol at 25°C.

[0072]

C. Strength at 90°C

A load-elongation curve is obtained under a heated atomosphere (90°C) with an initial sample length of 200 mm and a tensile speed of 200 mm/min with the condition shown in JIS L1013. Next, the value of the load at break is divided by an initial fineness and the obtained value is treated as strength, a strength-elongation curve is obtained by dividing elongation at break by the initial sample length and treating the obtained value as the degree of elongation, and the strength at a maximum point is treated as strength at 90°C.

[0073]

D. Shrinkage in boiling water

The shrinkage in boiling water is obtained from the following formula.

Shrinkage in boiling water (%) = [(L0-L1)/L0] x 100 (%)

(In the formula, L0 is the original length of a hank measured under an initial load of 0.09 cN/dtex after a hank of the drawn yarn is taken, and L1 is the length of a hank under an initial load of 0.09 cN/dtex after the hank in which L0 was measured is treated for 15 minutes in boiling water in the condition of load free and wind dried.)

E. CR value of a false-twisted yarn

A hank of the false-twisted yarn was taken, treated for 15 minutes in boiling water at the condition of practically load free, and wind-dried for 24 hours. A load equivalent to 0.088 cN/dtex (0.1 gf/d) is applied to this sample

and it is immersed in water, and a length of a hank L'0 after 2 minutes is measured. Next, a hank equivalent to 0.0088 cN/dtex is removed in water, changed to a small load equivalent to 0.0018 cN/dtex (2 mgf/d), and a length of a hank L'1 after 2 minutes is measured. Then, the CR value is calculated with the following formula.

CR (%) = [(L'0-L'1)/L'0] x 100 (%)

F. Non-untwisted number

10 m of the false-twisted yarn is drawn, the number of non-untwisted parts is counted visually, and it is treated as the non-untwisted number.

[0074]

G. D/Y, VR

The rotating speed (S) of the twisting body at the draw-friction false-twist process is measured by strobescope, the surface speed of the twisting body (S x LL) is obtained from the circumferential length (LL) of the twisting body, the velocity of the drawing roller is calculated with the following formula as a yarn-thread running speed (Y).

Three-axial friction false-twist type disk false-twisting device: D/Y = (S x LL)/Y

Belt nip type friction false-twisting device: VR = (S x LL)/Y

H. Evaluation of wear resistance

The dyed cloth obtained in the Examples and Comparative Examples is treated with the treatment condition described below following JIS L-1018 Taber method, the state of the surface wear is observed visually, a three-level evaluation was performed as ◎ being ones with almost no abrasion, ○ being ones with somewhat abrasion, and × being ones with severe abrasion, and ones with ○ or more are considered to pass the test.

Treatment condition

Material of a abrasion ring: No. CS-10

Pressing load: 2.45 N

Numbers of friction: 200 times

I. Total evaluation

From the non-untwisted number, the shrinkage in boiling water, the CR value, the strength at 90°C of the false-twisted yarn obtained in the Examples and Comparative Examples, dyeing unevenness, wear resistance property, and the generation of fluffing of the dyed cloth, a three-level evaluation is performed as ◎ being ones considered to be sufficiently applicable to production, ○ being ones considered to be applicable to production, and × being ones considered not to be applicable to production, and ones with ○ or more are considered to pass the test.

[0075]

[Production Example 1] (Production of polylactic acid)

A polymerization was performed on lactide produced from L lactic acid of optical pureness 99.5% under the existence of a bis(2-ethylhexanoate)tin catalyst (molar ratio of catalyst to lactide = 1/10000) at 1//79°C for 140 minutes under an atmosphere of nitrogen, and polylactic acid P1 was obtained. The weight-average molecular weight of the obtained polylactic acid was 145,000.

[0076]

[Production Example 2](Production of polylactic acid containing 4 wt% of EBA)

After polylactic acid P1 and ethylene bisstearic acid amide (EBA)

[manufactured by NOF CORPORATION, trade name: ALFLOW H-50S] were dried, the EBA which was heated and melted was measured to be P1 : EBA = 96 : 4 (weight ratio) and while continuously adding the EBA to P1, the mixture was supplied to a two-axial kneading extruder with a cylinder temperature of 220°C, and polylactic acid P2 including 4 wt% of EBA was obtained.

[0077]

[Production Example 3] (Production of polylactic acid containing 7 wt% of EBA)

Polylactic acid P3 containing 7 wt% of EBA was obtained in the same manner as Production Example 2 except that the weight ratio of polylactic acid P1 to ethylene bisstearic acid amide (EBA) was changed to P1 : EBA = 93 : 7 (weight ratio).

[0078]

[Production Example 4] (Production of polylactic acid containing 4 wt% of KBA)

Polylactic acid P4 containing 4 wt% of KBA was obtained in the same manner as Production Example 2 except that ethylene bisstearic acid amide (EBA) was changed to m-xylylene bisstearic acid amide (KBA) [manufactured by Nippon Kasei Chemical Co., Ltd., trade name: SLIPAX PXS].

[0079]

[Production Example 5] (Production of polylactic acid containing 4 wt% of SS)

Polylactic acid P5 containing 4 wt% of SS was obtained in the same manner as Production Example 2 except that ethylene bisstearic acid amide (EBA) was changed to n-stearyl stearic acid amide (SS) of an alkyl-substituted

type monoamide [manufactured by Nippon Kasei Chemical Co., Ltd., trade name: NIKKAMID S].

[00//79]

[Production Example 6] (Production of polylactic acid containing 4 wt% of BA)

Polylactic acid P6 containing 4 wt% of BA was obtained in the same manner as Production Example 2 except that ethylene bisstearic acid amide (EBA) was changed to behenic acid amide (BA) of monoamide [manufactured by NOF CORPORATION, trade name: ALFLOW B-10].

[0081]

[Production Example 7] (Production of polylactic acid containing 4 wt% of SA)

Polylactic acid P7 containing 4 wt% of SA was obtained in the same manner as Production Example 2 except that ethylene bisstearic acid amide (EBA) was changed to stearic acid amide (SA) of monoamide [manufactured by NOF CORPORATION, trade name: ALFLOW S-10].

[0082]

[Example 1]

After blending raw material chips to be polylactic acid P1 : polylactic acid P2 = 3 : 1 in weight ratio (EBA is 1.0 wt%) and performing vacuum drying while stirring at 100°C for 8 hours, the chips were charged in a hopper 1 of a spinning machine shown in Figure 1, after the chips were melted and extruded with an extruder type melting extruder 2 at 220°C, it was measured at 58.3 g/min with a measuring pump 3, the melted polymer was guided to a spinning pack 4 installed in a spin block 5 heated to 220°C, yarn-thread F was spanned

out from a spinneret 6 of 0.3 mm hole diameter, 0.5 mm hole depth, and 36 number of holes, the yarn-thread F was cooled to solidify by exposing the yarn-thread F to cooling wind at a speed of 25 m/min from a cooling device 7, the yarn-thread F was converged by an oil feeding apparatus 8, and at the same time, a finishing oil for spinning containing 85 wt% of a polyether-based lubricant [a butanol (ethylene oxide / propylene oxide) random addition, ethylene oxide / propylene oxide = 50 / 50 wt%, weight-average molecular weight 1,400] (concentration of the finishing oil component 15 wt%) was added so that the finishing oil component became 1.0 wt% to the total weight of the fibers. After that, an interlacing treatment was performed on the yarn-thread F with an air flow at pressure of 0.05 MPa with a fluid treatment apparatus 9. After that, the yarn-thread F was drawn out through a first take-up roller 10 of a circumferential velocity of 5,000 m/min (spinning speed 5,000 m/min) and a second take-up roller 11, and was wound up in the cheese 13 at a twill angle of 5.5° with a winding apparatus 12. The spinning property was good, yarn breakage and generation of fluffing were not observed, and there was almost no generation of fumes right under the spinneret. Further, an undrawn yarn of polylactic acid was unreeled from the obtained cheese 13, and the physical properties were measured. The total fineness was 117 dtex, the shrinkage in boiling water was 15%, and it had sufficient heat resistance.

[0083]

Then, the draw-friction false-twist process was performed with a draw-friction false-twisting apparatus shown in Figure 2. The yarn-thread F unreeled from the cheese 14 was supplied to a contact-type false-twisting heater heated to 130℃ from a supplying roller 16 of a circumferential velocity

of 428.6 m/min through yarn guides 15a, 15b, and 15c. After that, twisting was performed at a twisting body 20 of surface speed (D) of 900 m/min through a cooling plate 19 in which cooling water is circulated via the yarn guide 18. At this time, the twisting body 20 is a three-axial friction false-twisting tool in which the first to third disk materials are made of ceramic and the fourth to tenth disks are composed of urethane disks of hardness of 82 degree. After that, a yarn was taken-off with the draw roller 21 of a circumferential velocity of 600 m/min and the false-twisted yarn 24 of 84 dtex and 36 filaments was obtained through the delivery roller 22 of a circumferential velocity of 600 m/min and yarn guides 23a and 23b. Yarn guard property was good and a stable process was possible without occurrence of adhering tar and scum to the heater, the twister, and various guides. At this time, D/Y was 1.5, T1 was 0.15 cN/dtec, T2 was 0.23 cN/dtex, and T2/T1 was 1.53.

[0084]

The non-untwisted number of the obtained false-twisted yarn 24 was 0 spots, and it had sufficient migration and high uniformity. Further, the shrinkage in boiling water was 7.8%, the CR value was 20%, and it showed excellent dimensional stability and crimping property. Furthermore, the strength at 90°C was 1.0 cN/dtex and it had excellent heat resistance.

[0085]

A twill fabric (weaving density: 95 warps/inch and //79 wefts/inch) was manufactured using this false-twisted yarn as warps and wefts. Moreover, S twisting in which both the warps and the wefts are 300 turns/m was performed. At this time, there was almost no occurrence of yarn breakage and fluffing in the yarn twisting process and the cloth weaving process, and it showed excellent

ability to smoothly pass through processing steps. The dyeing process was performed on this cloth with the clothing process condition shown below. The obtained cloth has a flexible touch feeling, softness, and also sufficient bulkiness. Furthermore, it was an excellent cloth with less mechanical creaking touch due to an original property of the false-twisting yarn of polylactic acid and no dyeing unevenness. Further, the evaluation of wear resistance was performed, and there was little change on the surface and it showed excellent wear resistance. The result is shown in Table 1.

[Clothing Process Condition]

· Scouring: soda ash (1 g/1), surfactant (0.5 g/1), 98°C x 20 min.

· Intermediate set: 140°C x 3 min.

· Dyeing: Dianix Navy Blue ERFS 200 (2 wt%owf), pH adjuster (0.2 g/1), 110°C x 40 min.

· Sorbing: surfactant (0.2 g/1), 60°C x 20 min.

· Finishing set: 140°C x 30 min.

[Example 2]

The undrawn yarn and the false-twisted yarn of polylactic acid and dyed cloth made from these yarns were obtained with the same method as Example 1 except that only polylactic acid P2 was used as a raw material. At this time, generation of fumes at a small amount was observed in the melt-spinning process to obtain the undrawn yarn of polylactic acid. However, productivity and operational environment were able to endure in practical use. For the fiber physical properties of the obtained undrawn yarn of polylactic acid, a total fineness was 17 dtex, a shrinkage in boiling water was 15%, and excellent heat resistance was shown. Further, the false-twisted yarn had the

total fineness of 84 dtex, the shrinkage in boiling water of 7.7%, the CR value of 20%, excellent dimensional stability and crimping property were shown, the non-untwisted number was 0 spots/10 m, and was excellent in uniformity of crimping shape. Furthermore, the strength at 90°C was 1.0 cN/dtex, and excellent heat resistance was shown. The dyed cloth had softness, a flexible touch feeling, and also sufficient bulkiness, and was a cloth of excellent grade without dyeing unevenness. Further, when the evaluation of wear resistance was performed, good wear resistance was shown with little change on the surface. The result is shown in Table 1.

[0086]

[Example 3]

False-twisted yarn and dyed cloth made from it were obtained with the same method as Example 1 except that polylactic acid P1 : polylactic acid P2 = 20 : 1 (EBA is 0.2 wt%) was used as a raw material. At this time, yarn breakage occurred several times in the draw-friction false-twist process to obtain a false-twisted yarn of polylactic acid. However, the draw-friction false-twist process was performed without a large problem. For the fiber physical properties of the obtained undrawn yarn of polylactic acid, the total fineness was 117 dtex, and the shrinkage in boiling water was 15%. Further, the false-twisted yarn had the total fineness of 84 dtex, the shrinkage in boiling water of 7.7%, the CR value of 21%, excellent dimensional stability and crimping property were shown, the non-untwisted number was 0 spots/10m, and was excellent in uniformity of crimping shape. Furthermore, the strength at 90°C was 1.0 cN/dtex, and excellent heat resistance was shown. The dyed cloth had softness, a flexible touch feeling, and also sufficient bulkiness, and a

cloth of excellent grade without dyeing unevenness was obtained. Further, when the evaluation of wear resistance was performed, good wear resistance was shown with little change on the surface. The result is shown in Table 1.

[0087]

[Comparative Example 1]

False-twisted yarn and dyed cloth made from it were obtained with the same method as Example 1 except that only polylactic acid P1 was used as a raw material. At this time, yarn breakage often occurred in the draw-friction false-twist process to obtain a false-twisted yarn of polylactic acid. However, the draw-friction false twist process was performed without a large problem. For the fiber physical properties of the obtained undrawn yarn of polylactic acid, the total fineness was 117 dtex, and the shrinkage in boiling water was 15%. Further, the false-twisted yarn had the total fineness of 84 dtex, the shrinkage in boiling water of 7.8%, the CR value of 20%, and excellent dimensional stability and crimping property were shown. Furthermore, the strength at 90°C was 0.9 cN/dtex, and excellent heat resistance was shown. However, the non-untwisted number was 4 spots/10m, and it was inferior in uniformity. Although the dyed cloth had softness, a flexible touch feeling, and also sufficient bulkiness, the dyeing unevenness was observed and the grade was poor. Further, when the evaluation of wear resistance was performed, it was not able to be in practical use because a trace of being shaved remained on the surface, tears occurred partially, etc. The result is shown in Table 1.

[0088]

[Comparative Example 2]

False-twisted yarn and dyed cloth made from it were obtained with

the same method as Example 1 except that only polylactic acid P3 (EBA is 7 wt%) was used as a raw material. At this time, bleeding-out of the lubricant was severe and the operational environment deteriorated remarkably in the melt-spinning process to obtain an undrawn yarn of polylactic acid. For the fiber physical properties of the obtained undrawn yarn of polylactic acid, the total fineness was 117 dtex, and the shrinkage in boiling water was 15%. Further, the false-twisted yarn had a total fineness of 84 dtex, a shrinkage in boiling water of 7.8%, a CR value of 20%, excellent dimensional stability and crimping property were shown, the non-untwisted number was 0 spots/10m, and was excellent in uniformity of crimping shape. Furthermore, the strength at 90°C was 0.8 cN/dtex, and excellent heat resistance was shown. Further, although the dyed cloth had softness, a flexible touch feeling, and also sufficient bulkiness, the dyeing unevenness was severe and the grade was poor. Further, when the evaluation of wear resistance was performed, a part durable to friction partially was observed. However, there was part in which tears occurred and wear resistance was poor. The result is shown in Table 1.

[0089]

[Table 1]

	Example 1	Example 2	Example 3	Comparative example 1	Comparative example 2
Type of lubricant	EBA	EBA	EBA	---	EBA
Adding amount of lubricant (wt%)	1.0	4.0	0.2	0.0	7.0
Method for adding	Prior kneading Chip blending	Chip blending only	Prior kneading Chip blending	---	Chip blending only
Velocity of first take-up roller (m/min)	5000	5000	5000	5000	5000
Main component of finishing oil for spinning	Polyether-based	Polyether-based	Polyether-based	Polyether-based	Polyether-based
Containing amount of main component (wt%)	85	85	85	85	85
Shrinkage in boiling water of undrawn yarn (%)	15	15	15	15	15
D/Y, VR (-)	1.5	1.5	1.5	1.5	1.5
T2/T1 (-)	1.53	1.53	1.53	1.83	1.53
Temperature of false-twisting heater (°C)	130	130	130	130	130
Type and material of twisting	Three-axial,	Three-axial,	Three-axial,	Three-axial,	Three-axial,

body	Urethane	Urethane	Urethane	Urethane	Urethane
Hardness of twisting body	82	82	82	82	82
CR value (%)	20	20	21	20	20
Strength at 90°C (cN/dtex)	1.0	1.0	1.0	0.9	0.8
Shrinkage in boiling water of false-twisted yarn (%)	7.8	7.7	7.7	7.8	7.8
Non-untwisted number	0	0	0	4	0
Evaluation of wear resistance	◎	◎	◎	×	×
Total evaluation	◎	◎	◎	×	×

[0090]

[Example 4]

False-twisted yarn and dyed cloth made from it were obtained with the same method as Example 1 except that polylactic acid P1 : polylactic acid P4 = 3 : 1 (KBA is 1.0 wt%) was used as a raw material. At this time, in both the spinning process and false-twisting process, good ability to smoothly pass through processing steps was shown. At this time, the shrinkage in boiling water of the undrawn yarn of polylactic acid was 15%. For the obtained false-twisted yarn of polylactic acid, the total fineness was 84 dtex, the shrinkage in boiling water was 7.9%, the CR value was 21%, and excellent dimensional stability and crimping property were shown. Further, the strength at 90°C was 1.0 cN/dtex, and excellent heat resistance was shown. The dyed cloth had softness, a flexible touch feeling, and also sufficient bulkiness, and was excellent without dyeing unevenness being observed. Furthermore, the non-untwisted number was 0 spots/10 m and it showed a uniform crimping shape in the longitudinal direction of the yarn. Further, when the evaluation of wear resistance was performed, excellent wear resistance was shown with little change on the surface. The result is shown in Table 2.

[0091]

[Example 5]

False-twisted yarn and dyed cloth made from it were obtained with the same method as Example 1 except that polylactic acid P1 : polylactic acid P5 = 3 : 1 (SS is 1.0 wt%) was used as a raw material. At this time, in both the spinning process and false-twisting process, good ability to smoothly pass

through processing steps was shown. The shrinkage in boiling water of the obtained undrawn yarn of polylactic acid was 15%. Further, for the obtained false-twisted yarn of polylactic acid, the total fineness was 84 dtex, the shrinkage in boiling water was 7.8%, the CR value was 20%, excellent dimensional stability and crimping property were shown. Further, the strength at 90°C was 1.0 cN/dtex, excellent heat resistance was shown, the non-untwisted number was 0 spots/10m and it was excellent in uniformity of crimping shape. Furthermore, the non-untwisted number was 0 spots/10m and a uniform crimping shape was shown in the longitudinal direction of the yarn. The dyed cloth had softness, a flexible touch feeling, and also sufficient bulkiness, and was excellent without dyeing unevenness. Further, when the evaluation of wear resistance was performed, excellent wear resistance was shown with little change on the surface. The result is shown in Table 2.

[0092]

[Comparative Example 3]

False-twisted yarn and dyed cloth made from it were obtained with the same method as Example 1 except that polylactic acid P1 : polylactic acid P6 = 3 : 1 (BA is 1.0 wt%) was used as a raw material. In the spinning process, fumes were generated and the operational environment was deteriorated, and in the false-twisting process, yarn breakage often occurred. The shrinkage in boiling water of the obtained undrawn yarn of polylactic acid was 15%. Further, for the obtained false-twisted yarn of polylactic acid, the total fineness was 84 dtex, the shrinkage in boiling water was 7.8%, the CR value was 20%, excellent dimensional stability and crimping property were shown, the strength at

90°C was 0.8 cN/dtex, and sufficient heat resistance was shown. However, the non-untwisted number was 5 spots/10 m and the grade was poor. The dyed cloth had sufficient bulkiness. However, it has a less soft feeling and lack of a flexible touch feeling, and the grade was poor with dyeing unevenness being observed. Further, when the evaluation of wear resistance was performed, shaving occurred on the surface and wear resistance deteriorated. The result is shown in Table 2.

[0093]

[Comparative Example 4]

False-twisted yarn and dyed cloth made from it were obtained with the same method as Example 1 except that polylactic acid P1 : polylactic acid P7 = 3 : 1 (SA is 1.0 wt%) was used as a raw material. In the spinning process, fumes were generated and the operational environment was deteriorated, and in the false-twisting process, yarn breakage often occurred. The shrinkage in boiling water of the obtained undrawn yarn of polylactic acid was 15%. Further, for the obtained false-twisted yarn of polylactic acid, the total fineness was 84 dtex, the shrinkage in boiling water was 7.8%, the CR value was 20%, excellent dimensional stability and crimping property were shown, the strength at 90°C was 0.8 cN/dtex, and sufficient heat resistance was shown. However, the non-untwisted number was 5 spots/10 m and the grade was poor. The dyed cloth had sufficient bulkiness. However, it has a less soft feeling and lack of a flexible touch feeling, and the grade was poor with dyeing unevenness being observed. Further, when the evaluation of wear resistance was performed, shaving occurred on the surface and wear resistance deteriorated. The result

is shown in Table 2.

[0094]

[Table 2]

	Example 4	Example 5	Comparative example 3	Comparative example 4
Type of lubricant	KBA	SS	BA	SA
Adding amount of lubricant (wt%)	1.0	1.0	1.0	1.0
Method for adding	Prior kneading Chip blending	Prior kneading Chip blending	Prior kneading Chip blending	Prior kneading Chip blending
Velocity of first take-up roller (m/min)	5000	5000	5000	5000
Main component of finishing oil for spinning	Polyether-based	Polyether-based	Polyether-based	Polyether-based
Containing amount of main component (wt%)	85	85	85	85
Shrinkage in boiling water of undrawn yarn (%)	15	15	15	15
D/Y, VR (-)	1.5	1.5	1.5	1.5
T2/T1 (-)	1.53	1.53	1.83	1.53
Temperature of false-twisting heater (°C)	130	130	130	130
Type and material of twisting body	Three-axial, Urethane	Three-axial, Urethane	Three-axial, Urethane	Three-axial, Urethane
Hardness of twisting body	82	82	82	82
CR value (%)	21	20	20	20
Strength at 90°C (cN/dtex)	1.0	1.0	0.8	0.8
Shrinkage in boiling water of false-twisted yarn (%)	7.9	7.8	7.8	7.8
Non-untwisted number	0	0	5	5
Evaluation of wear resistance	◎	◎	×	×
Total evaluation	◎	◎	×	×

[0095]

[Example 6]

False-twisted yarn and dyed cloth made from it were obtained with the same method as Example 1 except that in the melt-spinning process, the melted polymer was measured at 62.5 g/min with a measuring pump, the velocity of the first take-up roller was 6,000 m/min, and in the draw friction false-twist process, the velocity of the supplying roller was 480 m/min and D/Y was 1.7. In the melt-spinning process, a small amount of yarn breakage occurred. However, stable reeling was possible. The shrinkage in boiling water of the obtained undrawn yarn of polylactic acid was 12%. Further, T2 / T1 in the draw-friction false-twist process was 1.4. For the obtained false-twisted yarn, the shrinkage in boiling water was 6.5%, the CR value was 23%, and it showed excellent dimensional stability and crimping property. Furthermore, the strength at 90°C was 1.1 cN/dtex, it was excellent in heat resistance, the non-untwisted number was 0 spots/10 m, and it had a uniform crimping shape. The dyed cloth was produced using this false-twisted yarn with the same method as Example1, and it had excellent bulkiness, a soft feeling, and a flexible touch feeling, and it was without dyeing unevenness. Further, when the evaluation of wear resistance was performed, it showed excellent wear resistance with little change on the surface. The result is shown in Table 3.

[0096]

[Example 7]

False-twisted yarn and dyed cloth made from it were obtained

with the same method as Example 1 except that in the melt-spinning process, the melted polymer was measured at 51.2 g/min with a measuring pump, the velocity of the first take-up roller was 4,300 m/min, and in the draw-friction false-twist process, the velocity of the supplying roller was 419.6 m/min and D/Y was 1.4. At this time, in both the spinning process and the false-twisting process, it showed good ability to smoothly pass through processing steps. The shrinkage in boiling water of the obtained undrawn yarn of polylactic acid was 17%. Further, T2 / T1 in the draw-friction false-twist process was 1.93. For the obtained false-twisted yarn, the shrinkage in boiling water was 7.6%, the CR value was 19%, and it showed excellent dimensional stability and crimping property. Furthermore, the strength at 90°C was 0.9 cN/dtex, it was excellent in heat resistance, the non-untwisted number was 1 spots/10 m and it showed a sufficient uniform crimping shape even though it was inferior to Example 1. The dyed cloth was produced using this false-twisted yarn with the same method as Example1, and it had good bulkiness, a soft feeling, and a flexible touch feeling, and it had an extremely small amount of dyeing unevenness. Further, when the evaluation of wear resistance was performed, it showed excellent wear resistance with little change on the surface. The result is shown in Table 3.

[0097]

[Example 8]

False-twisted yarn and dyed cloth made from it were obtained with the same method as Example 1 except that in the melt-spinning process, the melted polymer was measured at 50.0 g/min with a measuring pump, the

velocity of the first take-up roller was 4000 m/min, and in the draw-friction false-twist process, the velocity of the supplying roller was 400 m/min and D/Y was 1.3. At this time, in both the spinning process and the false-twisting process, it showed good ability to smoothly pass through processing steps. The shrinkage in boiling water of the obtained undrawn yarn of polylactic acid was 19%. Further, T2 / T1 in the draw-friction false-twist process was 2.25. For the obtained false-twisted yarn, the shrinkage in boiling water was 6.5%, the CR value was 23%, and it showed excellent dimensional stability and crimping property. Furthermore, the strength at 90°C was 0.7 cN/dtex, it had a good heat resistance, the non-untwisted number was 3 spots/10 m and it showed a uniform crimping shape that had a level of practically no problem even though it was inferior to Example 1. The dyed cloth was produced using this false-twisted yarn with the same method as Example 1, and it had excellent bulkiness, a soft feeling, and a flexible touch feeling, and it was with little dyeing unevenness. Further, when the evaluation of wear resistance was performed, it showed excellent wear resistance with less change on the surface. The result is shown in Table 3.

[0098]

[Comparative Example 5]

False-twisted yarn and dyed cloth made from it were obtained with the same method as Example 1 except that in the melt-spinning process, the melted polymer was measured at 52.6 g/min with a measuring pump, the velocity of the first take-up roller was 3,500 m/min, and in the draw-friction false-twist process, the velocity of the supplying roller was 333 m/min and D/Y

was 0.67. At this time, in the spinning process, it showed good passability. However, in the draw-friction false-twist process, yarn breakage occurred frequently on the false-twisting heater. The shrinkage in boiling water of the obtained undrawn yarn of polylactic acid was 50%. Further, the non-untwisted spots occurred frequently if the portion of T2 was made high, T2 / T1 was 3.40, and a large T2 was not applied on the yarn-thread after the twisting body. For the obtained false-twisted yarn, the shrinkage in boiling water was 7%, the CR value was 9%, and it showed excellent dimensional stability. However, it was inferior in crimping property. Furthermore, the strength at 90°C was 0.35 cN/dtex, it had a poor heat resistance, the non-untwisted number was 7 spots/10 m and it was inferior to Example 1 in uniformity of crimping shape. The dyed cloth was produced using this false-twisted yarn with the same method as Example 1, a paper-like cloth without bulkiness was obtained, dyeing unevenness occurred frequently, and the grade was poor. Further, when the evaluation of wear resistance was performed, shaving occurred on the surface and it was a little inferior in wear resistance compared to Example 1. The result is shown in Table 3.

[0099]

[Table 3]

	Example 4	Example 5	Comparative example 3	Comparative example 4
Type of lubricant	KBA	SS	BA	SA
Adding amount of lubricant (wt%)	1.0	1.0	1.0	1.0
Method for adding	Prior kneading Chip blending	Prior kneading Chip blending	Prior kneading Chip blending	Prior kneading Chip blending
Velocity of first take-up roller (m/min)	5000	5000	5000	5000
Main component of finishing oil for spinning	Polyether-based	Polyether-based	Polyether-based	Polyether-based
Containing amount of main component (wt%)	85	85	85	85
Shrinkage in boiling water of undrawn yarn (%)	15	15	15	15
D/Y, VR (-)	1.5	1.5	1.5	1.5
T2/T1 (-)	1.53	1.53	1.83	1.53
Temperature of false-twisting heater (°C)	130	130	130	130
Type and material of twisting body	Three-axial, Urethane	Three-axial, Urethane	Three-axial, Urethane	Three-axial, Urethane
Hardness of twisting body	82	82	82	82
CR value (%)	21	20	20	20
Strength at 90°C (cN/dtex)	1.0	1.0	0.8	0.8
Shrinkage in boiling water of false-twisted yarn (%)	7.9	7.8	7.8	7.8
Non-untwisted number	0	0	5	5
Evaluation of wear resistance	◎	◎	×	×
Total evaluation	◎	◎	×	×

[0100]

[Example 9]

False-twisted yarn and dyed cloth made from it were obtained with the same method as Example 1 except that the containing amount of a polyether-based lubricant [a butanol (ethylene oxide / propylene oxide) random addition, ethylene oxide / propylene oxide = 50 / 50 wt%, weight-average molecular weight 1,400] included in a finishing oil for spinning was 65 wt%. The shrinkage in boiling water of the obtained undrawn yarn of polylactic acid was 15%. For the false-twisted yarn of polylactic acid, the total fineness was 84 dtex, the shrinkage in boiling water was 7.7%, the CR value was 20%, and it showed excellent dimensional stability and crimping property. Further, the strength at 90°C was 1.0 cN/dtex and it showed excellent heat resistance. However, the non-untwisted number became 1 spot/10 m and the uniformity of the crimping shape was inferior to Example 1 a small amount. The dyed cloth had bulkiness, an excellent soft feeling and a flexible touch feeling, and it was good with almost no dyeing unevenness. Further, when the evaluation of wear resistance was performed, it showed good wear resistance with little change on the surface. The result is shown in Table 4.

[0101]

[Example 10]

False-twisted yarn and dyed cloth made from it were obtained with the same method as Example 1 except that the containing amount of a polyether-based lubricant [a butanol (ethylene oxide / propylene oxide) random addition, ethylene oxide / propylene oxide = 50 / 50 wt%, weight-average

molecular weight 1,400] included in a finishing oil for spinning was 45 wt%. The shrinkage in boiling water of the obtained undrawn yarn of polylactic acid was 15%. For the false-twisted yarn of polylactic acid, the total fineness was 84 dtex, the shrinkage in boiling water was 7.8%, the CR value was 20%, and it showed excellent dimensional stability and crimping property. Further, the strength at 90°C was 1.0 cN/dtex and it showed excellent heat resistance. However, the non-untwisted number of the false-twisted yarn of polylactic acid became 3 spots/10 m and it was inferior to Example 1 in the uniformity of the crimping shape . Although the dyed cloth had an excellent bulkiness, soft feeling and a flexible touch feeling, dyeing unevenness was observed at a small amount to a level of practically no problem. However, when the evaluation of wear resistance was performed, it showed good wear resistance with little change on the surface. The result is shown in Table 4.

[0102]

[Comparative Example 6]

False-twisted yarn was obtained with the same method as Example 1 except that the finishing oil for spinning contained fatty acid ester-based lubricant (equal amount of isotridecyl stearate and octyl palmtate) 40 wt%, a mineral oil 15 wt%, and polyhydric alcohol ester 20 as an emulsifier 20 wt%. In the melt-spinning process, it showed good ability to smoothly pass through processing steps. However, when a continuous drive was performed in the draw-friction false-twist process, the finishing oil adhered on the surface of the twisting body, the false-twisting heater, and yarn guides, and the crimping shape differed in a large amount between the beginning and the end of the

drive. Further, for the fiber property of the obtained false-twisted yarn, the shrinkage in boiling water was 7.9%, the CR value was 19%, it showed excellent dimensional stability and crimping property, the strength at 90C was 0.6 cN/dtex, and it had heat resistance that was no problem in practical use. However, the non-untwisted number was a very large number, 8 spots/10 m, and the grade was poor. Further, when the dyed cloth was produced in the same manner as Example 1, sufficient bulkiness was not obtained, dyeing unevenness occurred frequently, and the grade was poor. Further, when the evaluation of wear resistance was performed, shaving occurred on the surface and it was a little inferior in wear resistance compared to Example 1. The result is shown in Table 4.

[0103]

[Table 4]

	Example 9	Example 10	Comparative example 6
Type of lubricant	EBA	EBA	EBA
Adding amount of lubricant (wt%)	1.0	1.0	1.0
Method for adding	Prior kneading Chip blending	Prior kneading Chip blending	Prior kneading Chip blending
Velocity of first take-up roller (m/min)	5000	5000	5000
Main component of finishing oil for spinning	Polyether-based	Polyether-based	Fatty acid ester-based

Containing amount of main component (wt%)	65	45	40
Shrinkage in boiling water of undrawn yarn (%)	15	15	15
D/Y, VR (-)	1.5	1.5	1.5
T2/T1 (-)	1.53	1.53	1.53
Temperature of false-twisting heater (°C)	130	130	130
Type and material of twisting body	Three-axial, Urethane	Three-axial, Urethane	Three-axial, Urethane
Hardness of twisting body	82	82	82
CR value (%)	20	20	19
Strength at 90°C (cN/dtex)	1.0	1.0	0.6
Shrinkage in boiling water of false-twisted yarn (%)	7.7	7.8	7.9
Non-untwisted number	1	3	8
Evaluation of wear resistance	◎	◎	○
Total evaluation	○	○	×

[0104]

[Example 11]

False-twisted yarn was obtained with the same method as Example 1 except that D/Y was 2.33. At this time, in the draw-friction false-twist process, it showed good ability to smoothly pass through processing steps, and T2 / T1 in the draw-friction false-twist process was 0.69. Further, for the obtained false-twisted yarn, the shrinkage in boiling water was 7.8%, the CR value was 16%, it showed excellent dimensional stability and good crimping property, the strength at 90°C was 0.8 cN/dtex, and it showed good heat resistance. However, the non-untwisted number was 3 spots/10 m and uniformity of the crimping shape was a little inferior to Example 1. Further, the dyed cloth was produced in the same manner as Example 1, dyeing unevenness was observed in a small amount. However, bulkiness, soft feeling, and flexible touch feeling were good, and when the evaluation of wear resistance, it showed excellent wear resistance with little change on the surface. The result is shown in Table 5.

[0105]

[Example 12]

False-twisted yarn was obtained with the same method as Example 1 except that D/Y was 1.08. At this time, in the draw-friction false-twist process, yarn breakage often occurred between the twisting body and the drawing roller. Further, T2 / T1 in the draw-friction false-twist process was 2.96 and the portion of T2 was high. Further, for the obtained false-twisted yarn, the shrinkage in boiling water was 7.8%, the CR value was 18%, it showed excellent dimensional stability and good crimping property, the strength at 90°C was 0.8 cN/dtex, it showed good heat resistance, the non-untwisted

number was 0 spots/10 m, and it showed excellent uniformity of the crimping shape. However, fluffing occurred in a small amount. Further, the dyed cloth was produced in the same manner as Example 1, and fluffing was observed in a small amount. However, bulkiness, soft feeling, and flexible touch feeling, the level of dyeing unevenness were good, and when the evaluation of wear resistance, it showed excellent wear resistance with little change on the surface. The result is shown in Table 5.

[0106]

[Comparative Example 7]

False-twisted yarn was obtained with the same method as Example 1 except that D/Y was 0.67. At this time, in the draw-friction false-twist process, yarn breakage occurred frequently between the twisting body and the drawing roller. Further, T2 / T1 in the draw-friction false-twist process was 3.26 and the portion of T2 was very high. Further, for the obtained false-twisted yarn, the shrinkage in boiling water was 7.7%, the CR value was 20%, it showed excellent dimensional stability and good crimping property, the strength at 90°C was 0.8 cN/dtex, it had good heat resistance, the non-untwisted number was 0 spots/10 m, and it showed excellent uniformity of the crimping shape. However, fluffing occurred frequently. Further, the dyed cloth was produced in the same manner as Example 1, and bulkiness, soft feeling, and flexible touch feeling were good. However, dyeing unevenness was observed, fluffing existed on the surface of the cloth, and the grade was poor. Further, fluffing accumulated in the twisting process and in the cloth weaving process, and the twisting machine and the weaving machine had to be

stopped often. Further, when the evaluation of wear resistance was performed, shaving was large on the surface of the cloth and wear resistance was poor. The result is shown in Table 5.

[0107]

[Table 5]

	Example 11	Example 12	Comparative example 7
Type of lubricant	EBA	EBA	EBA
Adding amount of lubricant (wt%)	1.0	1.0	1.0
Method for adding	Prior kneading Chip blending	Prior kneading Chip blending	Prior kneading Chip blending
Velocity of first take-up roller (m/min)	5000	5000	5000
Main component of finishing oil for spinning	Polyether-based	Polyether-based	Polyether-based
Containing amount of main component (wt%)	85	85	85
Shrinkage in boiling water of undrawn yarn (%)	15	15	15
D/Y, VR (-)	2.33	1.08	0.67
T2/T1 (-)	0.69	2.96	3.26
Temperature of	130	130	130

false-twisting heater (°C)			
Type and material of twisting body	Three-axial, Urethane	Three-axial, Urethane	Three-axial, Urethane
Hardness of twisting body	82	82	82
CR value (%)	16	18	20
Strength at 90°C (cN/dtex)	0.8	0.8	0.8
Shrinkage in boiling water of false-twisted yarn (%)	7.8	7.7	7.7
Non-untwisted number	3	0	0
Evaluation of wear resistance	◎	◎	×
Total evaluation	○	○	×

[0108]

[Example 13]

False-twisted yarn was obtained with the same method as Example 1 except that the temperature of the twisting heater was 95°C. At this time, in the draw-friction false-twist process, it showed good ability to smoothly pass through processing steps, and T2 / T1 in the draw friction false twist process was 0.8. Further, for the obtained false-twisted yarn of polylactic acid, the shrinkage in boiling water was 14%, the CR value was 16%, it showed dimensional stability without any problem in practical use and good crimping

property, the strength at 90°C was 0.6 cN/dtex, and it had heat resistance without any problem in practical use. Further, the non-untwisted number was 0 spots/10 m and it was excellent in the uniformity of the crimping shape. Furthermore, the dyed cloth was produced in the same manner as Example 1, and bulkiness and the level of dyeing unevenness were excellent. However, soft feeling and flexible touch feeling were a little poor. Further, when the evaluation of wear resistance was performed, it showed excellent wear resistance with little change on the surface. The result is shown in Table 6.

[0109]

[Example 14]

False-twisted yarn was obtained with the same method as Example 1 except that the temperature of the twisting heater was 145°C. At this time, in the draw-friction false-twist process, it showed good ability to smoothly pass through processing steps, and T2 / T1 in the draw-friction false-twist process was 2.8. Further, for the obtained false-twisted yarn of polylactic acid, the shrinkage in boiling water was 5%, the CR value was 11.2%, and it showed dimensional stability without any problem in practical use and good crimping property. Furthermore, the strength at 90°C was 0.9 cN/dtex, and it had excellent heat resistance. Further, the non-untwisted number was 0 spots/10 m and it was excellent in the uniformity of the crimping shape. Furthermore, the dyed cloth was produced in the same manner as Example 1, it had bulkiness, softness, and flexible touch feeling without any problem in practical use, and a cloth without dyeing unevenness was obtained. Further, when the evaluation of wear resistance was performed, it showed excellent wear

resistance with little change on the surface. The result is shown in Table 6.

[0110]

[Comparative Example 8]

False-twisted yarn was obtained with the same method as Example 1 except that the temperature of the twisting heater was 85°C. At this time, in the draw-friction false-twist process, it showed good ability to smoothly pass through processing steps, and T2 / T1 in the draw-friction false-twist process was 0.7. Further, the non-untwisted number of the obtained false-twisted yarn of polylactic acid was 0 spots/10 m, it was excellent in uniformity of crimping shape, the CR value was 18%, the strength at 90°C was 0.6 cN/dtex, and it showed good crimping property and heat resistance without any problem in practical use. However, the shrinkage in boiling water was high being 17%, and it was inferior in dimensional stability. Furthermore, the dyed cloth was produced in the same manner as Example 1, it was excellent in bulkiness and level of dyeing unevenness. Further, when the evaluation of wear resistance was performed, it showed good wear resistance with little change on the surface. However, it was inferior in softness and flexible touch feeling, and the grade was poor. The result is shown in Table 6.

[0111]

[Comparative Example 9]

False-twisted yarn was obtained with the same method as Example 1 except that the temperature of the twisting heater was 155°C. At this time, in the draw-friction false-twist process, it showed good ability to smoothly pass through processing steps, T2 / T1 in the draw-friction false-twist process was

3.1, and the portion of T2 was high Further, for the obtained false-twisted yarn of polylactic acid, the shrinkage in boiling water was 4.8% in boiling water, the strength at 90°C was 0.7 cN/dtex, the CR value was 8%, it was excellent in dimensional stability, and heat resistance was good. However, crimping property was deteriorated. Further, the non-untwisted number was a level without any problem in practical use, being 3 spots/10m. The dyed cloth was produced in the same manner as Example 1 using this false-twisted yarn of polylactic acid, the evaluation of wear resistance was performed, and it showed good wear resistance with little change on the surface. However, it was paper-like and the grade was poor lacking bulkiness. The result is shown in Table 6.

[0112]

[Table 6]

	Example 13	Example 14	Comparative example 8	Comparative example 9
Type of lubricant	EBA	EBA	EBA	EBA
Adding amount of lubricant (wt%)	1.0	1.0	1.0	1.0
Method for adding	Prior kneading Chip blending	Prior kneading Chip blending	Prior kneading Chip blending	Prior kneading Chip blending
Velocity of first take-up roller (m/min)	5000	5000	5000	5000
Main component of finishing oil for spinning	Polyether-based	Polyether-based	Polyether-based	Polyether-based
Containing amount of main component (wt%)	85	85	85	85
Shrinkage in boiling water of undrawn yarn (%)	15	15	15	15
D/Y, VR (-)	1.5	1.5	1.5	1.5
T2/T1 (-)	0.8	2.8	0.7	3.1
Temperature of false-twisting heater (°C)	95	145	85	155
Type and material of twisting	Three-axial,	Three-axial,	Three-axial,	Three-axial,

body	Urethane	Urethane	Urethane	Urethane
Hardness of twisting body	82	82	82	82
CR value (%)	16	11.2	18	8
Strength at 90°C (cN/dtex)	0.6	0.9	0.6	0.7
Shrinkage in boiling water of false-twisted yarn (%)	14	5	17	4.8
Non-untwisted number	0	0	0	0
Evaluation of wear resistance	◎	◎	◎	◎
Total evaluation	○	○	×	×

[0113]

[Example 15]

False-twisted yarn and dyed cloth made from it were obtained with the same method as Example 1 except that the twisting body was changed to a belt nip type friction false-twisting tool, the belt was made with a nitrile butylenes rubber having a hardness of 70 degree, the crossing angle of the belt was 100°, D/Y was VR, and its value was 1.5. At this time, in the draw-friction false-twist process, the yarn twisting process, and the cloth weaving process, it showed good ability to smoothly pass through processing steps. Further, for the value of the physical properties of the false-twisted yarn of polylactic acid, the shrinkage in boiling water was 7.8%, the CR value was 20%, the strength at 90°C was 1.0 cN/dtex, and it showed excellent dimensional stability, crimping property, and heat resistance. Furthermore, the non-untwisted number was 0 spots/10 m and it was a yarn without any fault in the longitudinal direction of the yarn. Further, the dyed cloth was excellent in bulkiness, soft feeling, and flexible touch feeling, and the excellent grade was shown without dyeing unevenness. Further, when the evaluation of wear resistance was performed, it showed excellent wear resistance with little change on the surface. The result is shown in Table 7.

[0114]

[Example 16]

False-twisted yarn and dyed cloth made from it were obtained with the same method as Example 1 except that the twisting body was a three-axial friction false-twisting type desk false-twisting tool, and material of the fourth to

the tenth desks was urethane having a hardness of 76 degree in JIS A scale. At this time, in the draw-friction false-twist process, , the yarn twisting process, and the cloth weaving process, it showed good ability to smoothly pass through processing steps. For the value of the physical properties of the false-twisted yarn of polylactic acid, the shrinkage in boiling water was 7.8%, the CR value was 20%, the strength at 90°C was 1.0 cN/dtex, and it showed excellent dimensional stability, crimping property, and heat resistance. Furthermore, the non-untwisted number was 0 spots/10 m and it was a yarn without any fault in the longitudinal direction of the yarn. Further, the dyed cloth was excellent in bulkiness, soft feeling, and flexible touch feeling, and the excellent grade was shown without dyeing unevenness. When the evaluation of wear resistance was performed, it showed excellent wear resistance with little change on the surface. The result is shown in Table 7.

[0115]

[Example 17]

False-twisted yarn and dyed cloth made from it were obtained with the same method as Example 1 except that the twisting body was a three-axial friction false-twisting type desk false-twisting tool, and material of the fourth to the tenth desks was urethane having a hardness of 89 degree in JIS A scale. At this time, in the draw-friction false-twist process, the yarn twisting process, and the cloth weaving process, it showed good ability to smoothly pass through processing steps. For the value of the physical properties of the false-twisted yarn of polylactic acid, the shrinkage in boiling water was 7.8%, the CR value was 20%, the strength at 90°C was 1.0 cN/dtex, and it showed excellent

dimensional stability, crimping property, and heat resistance. Furthermore, the non-untwisted number was 0 spots/10 m and it was a yarn without any fault in the longitudinal direction of the yarn. When the evaluation of wear resistance was performed, it showed excellent wear resistance with little change on the surface. Further, the dyed cloth was excellent in bulkiness, soft feeling, and flexible touch feeling, and was without dyeing unevenness. The result is shown in Table 7.

[0116]

[Example 18]

False-twisted yarn was obtained with the same method as Example 1 except that the twisting body was a belt nip type friction false-twisting tool, the belt was made of a nitrile butylenes rubber (NBR) having a hardness of 62 degree, D/Y was VR, and its value was 1.5. At this time, in the draw-friction false-twist process, the yarn twisting process, and the cloth weaving process, it showed good ability to smoothly pass through processing steps. Further, for the value of the physical properties of the false-twisted yarn of polylactic acid, the shrinkage in boiling water was 7.8%, the CR value was 20%, the strength at 90°C was 1.0 cN/dtex, and it showed excellent dimensional stability, crimping property, and heat resistance. Furthermore, the non-untwisted number was 0 spots/10 m and it was a yarn without any fault in the longitudinal direction of the yarn. Further, the dyed cloth was excellent in bulkiness, soft feeling, and flexible touch feeling, and the excellent grade was shown without dyeing unevenness. Further, when the evaluation of wear resistance was performed, it showed excellent wear resistance with little change on the surface. The

result is shown in Table 7.

[0117]

[Example 19]

False-twisted yarn and dyed cloth made from it were obtained with the same method as Example 1 except that the twisting body was a belt nip type friction false-twisting tool, the belt was made of a nitrile butylenes rubber (NBR) having a hardness of 82 degree, the crossing angle of the belt was 100°, D/Y was VR, and its value was 1.5. At this time, in the draw-friction false-twist process, the yarn twisting process, and the cloth weaving process it showed good ability to smoothly pass through processing steps. For the value of the physical properties of the false-twisted yarn, the shrinkage in boiling water was 7.8%, the CR value was 20%, the strength at 90°C was 1.0 cN/dtex, it showed and excellent dimensional stability, crimping property, and heat resistance. Furthermore, the non-untwisted number was 0 spots/10 m and it was a yarn without any fault in the longitudinal direction of the yarn. Further, the dyed cloth was excellent in bulkiness, soft feeling, and flexible touch feeling, and was without dyeing unevenness. When the evaluation of wear resistance was performed, it showed good wear resistance with little change on the surface. The result is shown in Table 7.

[0118]

[Table 7]

	Example 15	Example 16	Example 17	Example 18	Example 19
Type of lubricant	EBA	EBA	EBA	EBA	EBA
Adding amount of lubricant (wt%)	1.0	1.0	1.0	1.0	1.0
Method for adding	Prior kneading Chip blending	Prior kneading Chip blending	Prior kneading Chip blending	Prior kneading Chip blending	Prior kneading Chip blending
Velocity of first take-up roller (m/min)	5000	5000	5000	5000	5000
Main component of finishing oil for spinning	Polyether-based	Polyether-based	Polyether-based	Polyether-based	Polyether-based
Containing amount of main component (wt%)	85	85	85	85	85
Shrinkage in boiling water of undrawn yarn (%)	15	15	15	15	15
D/Y, VR (-)	1.5	1.5	1.5	1.5	1.5
T2/T1 (-)	1.53	1.53	1.53	1.83	1.53
Temperature of false-twisting heater (°C)	130	130	130	130	130
Type and material of twisting body	Belt, NBR	Three-axial, Urethane	Three-axial, Urethane	Belt, NBR	Belt, NBR

Hardness of twisting body	70	76	89	82	82
CR value (%)	20	20	21	20	20
Strength at 90°C (cN/dtex)	1.0	1.0	1.0	1.0	1.0
Shrinkage in boiling water of false-twisted yarn (%)	7.8	7.8	7.8	7.8	7.8
Non-untwisted number	0	0	0	0	0
Evaluation of wear resistance	◎	◎	◎	◎	◎
Total evaluation	◎	○	○	○	○

[0119]

[Example 20]

False-twisted yarn and dyed cloth made from it were obtained with the same method as Example 1 except that P1 was used as a raw material, ethylene bisstearic acid amide (EBA) [manufactured by NOF CORPORATION, trade name: ALFLOW H-50S] was supplied in the middle of an extruder type melting extruder so that it was added at 1 wt% to the ejecting amount. At this time, in the melt-spinning process, the draw-friction false-twist process, the yarn twisting process, and the cloth weaving process, it showed good ability to smoothly pass through processing steps, and it was excellent with less coloring of the obtained false-twisted yarn of polylactic acid. Further, for the value of the physical properties of the obtained false-twisted yarn, the shrinkage in boiling water was 7.8%, the CR value was 20%, the strength at 90°C was 1.0 cN/dtex, and it showed excellent dimensional stability, crimping property, and heat resistance. Furthermore, the non-untwisted number was 0 spots/10 m and it was a yarn without any fault in the longitudinal direction of the yarn. Further, the dyed cloth was excellent in bulkiness, soft feeling, and flexible touch feeling, and was excellent in grade without dyeing unevenness. Further, when the evaluation of wear resistance was performed, it showed excellent wear resistance with little change on the surface. The result is shown in Table 8.

[0120]

[Example 21]

False-twisted yarn and dyed cloth made from it were obtained with

the same method as Example 1 except that P1 was used as a raw material, powder of ethylene bisstearic acid amide (EBA) [manufactured by NOF CORPORATION, trade name: ALFLOW H-50S] was measured so that it was added at 1 wt% to the preparing amount, and then it was supplied in the middle of the extruder type melting extruder by being adhered to polylactic acid P1 in the drying process. At this time, in the melt-spinning process, the draw-friction false-twist process, the yarn twisting process, and the cloth weaving process, it showed good ability to smoothly pass through processing steps. However, when the continuous drive was performed, the added amount of the lubricant was changed although it was a level without a problem in practical use. For the value of the physical properties of the obtained false-twisted yarn, the shrinkage in boiling water was 7.8%, the CR value was 20%, the strength at 90°C was 1.0 cN/dtex, and it showed excellent dimensional stability, crimping property, and heat resistance. Furthermore, the non-untwisted number was 0 spots/10 m and it was a yarn without any fault in the longitudinal direction of the yarn. Further, the dyed cloth was excellent in bulkiness, soft feeling, and flexible touch feeling. When the evaluation of wear resistance was performed, it showed excellent wear resistance with little change on the surface. The result is shown in Table 8.

[0121]

[Table 8]

	Example 20	Example 21
Type of lubricant	EBA	EBA
Adding amount of lubricant		

(wt%)		
Method for adding	Kneading at spinning extrusion	Adding at drying
Velocity of first take-up roller (m/min)	5000	5000
Main component of finishing oil for spinning	Polyether-based	Polyether-based
Containing amount of main component (wt%)	85	85
Shrinkage in boiling water of undrawn yarn (%)	15	15
D/Y, VR (-)	1.5	1.5
T2/T1 (-)	1.53	1.53
Temperature of false-twisting heater (°C)	130	130
Type and material of twisting body	Three-axial, Urethane	Three-axial, Urethane
Hardness of twisting body	82	82
CR value (%)	20	20
Strength at 90°C (cN/dtex)	1.0	1.0
Shrinkage in boiling water of false-twisted yarn (%)	7.8	7.7
Non-untwisted number	0	0

Evaluation of wear resistance	◎	◎
Total evaluation	◎	○

[0122]

[Example 22]

False-twisted yarn and dyed cloth made from it were obtained with the same method as Example 1 except that in the draw-friction false-twist process, a non-contact type heater was arranged between the drawing roller and the delivery roller as shown in Figure 2, its temperature was set to 200°C, and its circumferential velocity was set to 540 m/min. At this time, in the draw-friction false-twist process, the yarn twisting process, and the cloth weaving process, it showed good ability to smoothly pass through processing steps. For the obtained false-twisted yarn, the shrinkage in boiling water was 5.3%, the strength at 90°C was 0.9 cN/dtex, the CR value was 14%, and it showed excellent dimensional stability and heat resistance, and good crimping property. Further, the non-untwisted number was 0 spots/10 m and it was a yarn without any fault in the longitudinal direction of the yarn. Further, the dyed cloth was very soft, and had a flexible touch feeling and good bulkiness, and it was excellent in grade without dyeing unevenness. Furthermore, when the evaluation of wear resistance was performed, it showed excellent wear resistance with little change on the surface. The result is shown in Table 9.

[0123]

[Table 9]

	Example 22
Type of lubricant	EBA

Adding amount of lubricant (wt%)	1.0
Method for adding	Prior kneading Chip blending
Velocity of first take-up roller (m/min)	5000
Main component of finishing oil for spinning	Polyether-based
Containing amount of main component (wt%)	85
Shrinkage in boiling water of undrawn yarn (%)	15
D/Y, VR (-)	1.5
T2/T1 (-)	1.53
Temperature of false-twisting heater (°C)	130
Type and material of twisting body	Three-axial, Urethane
Hardness of twisting body	82
CR value (%)	14
Strength at 90°C (cN/dtex)	0.9
Shrinkage in boiling water of false-twisted yarn (%)	5.3
Non-untwisted number	0
Evaluation of wear	◎

resistance	
Total evaluation	◎

[0124]

[Effect of the Invention]

False-twisted yarn of polylactic acid that is excellent in crimping property and dimensional stability while being able to endure in use under a high temperature environment and in the field in which wear resistance is required can be obtained with the present invention.

[Brief Description of the Figures]

Figure 1 shows a schematic view of the spinning apparatus for preferably obtaining an undrawn yarn of polylactic acid.

Figure 2 shows a schematic view of the draw-friction false-twisting apparatus for preferably obtaining a false-twisted yarn of polylactic acid.

[Explanation of Symbols]

1. Hopper
2. Extruder type melt extruder
3. Measuring pump
4. Spin block
5. Spinning pack
6. Spinneret 6
7. Chimney
8. Oil feeding apparatus
9. Fluid treatment apparatus
10. First take-up roller
11. Second take-up roller

12. Winding apparatus S

13. Cheese

14. Cheese

15a to 15c. Yarn guide

16. Supplying roller

17. False-twisting roller

18. Yarn guide

19. Cooling plate

20. Twisting body

21. Drawing roller

22. Delivery roller

23a and 23b. Yarn guide

24. False-twisted yarn

[Document] ABSTRACT OF THE DISCLOSURE

[Problem to be Solved]

To provide a false-twisted yarn of polylactic acid that is excellent in ability to smoothly pass through processing steps and productivity, and can endure in use under a high temperature environment and in the field in which wear resistance is required, and is also excellent in crimping property and dimensional stability, and a method for producing it.

[Solution]

A false-twisted yarn of polylactic acid comprises polylactic acid fibers containing a fatty acid bisamide and/or an alkyl-substituted fatty acid monoamide in an amount of 0.1 to 5.0 wt% based on the whole fiber and has the following properties;

strength at 90°C ≧ 0.5 cN/dtex,

CR ≧ 10%, and

Non-untwisted number≦3 spots /10m

Fig. 1

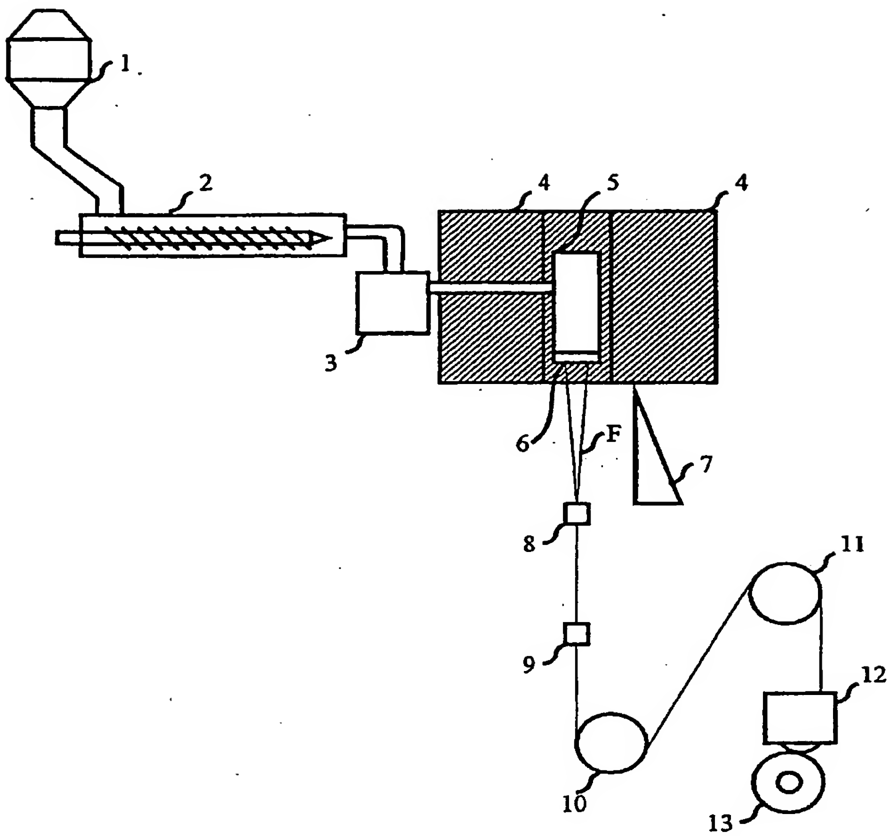

Fig. 2